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Productivity in transit: a new measure of labor productivity for urban transit systems

The U.S. Bureau of Labor Statistics productivity program introduces a new measure of labor productivity for urban transit systems. Urban transit systems, predominantly operated by state and local governments, include numerous modes of transportation, such as buses, subways, and light rail systems. This labor productivity index relies upon a volume-based index of industry services, which are defined as passenger miles traveled.

Brian Chansky
chansky.brian@bls.gov

Brian Chansky is an economist in the Office of Productivity and Technology, U.S. Bureau of Labor Statistics.

Nathan F. Modica
modica.Nathan@bls.gov

Nathan Modica is an economist in the Office of Productivity and Technology, U.S. Bureau of Labor Statistics.

This article introduces a new measure of labor productivity for urban transit systems, a predominantly public sector industry that provides intraurban passenger services on fixed routes and schedules. Labor productivity is a measure of economic performance that describes how efficiently an industry uses worker hours to produce goods or services. But measuring the services of industries within the public sector often requires a different approach from that of private sector industries.

Because the services of private sector industries produce revenue, the quantity of services can be deduced by deflating reported values of revenue with the appropriate measures of price. Within the U.S. Bureau of Labor Statistics (BLS) productivity program, this is known as the *deflated value* method of output measurement. However, while urban transit systems generate revenue from user fees (government services that produce revenue are known as *enterprise* services), this method of measurement is not ideal. Subsidies and uncompensated services prevent revenue from being an adequate proxy for quantity of service. Furthermore, revenue generation is not the singular goal of urban transit systems; their objectives (and limitations) can be fundamentally different from those of private firms.

In the United States, urban transit systems are managed predominantly by government enterprises at the local level.[1] These systems address a variety of specific local needs such as providing mobility services for the poor, reducing traffic congestion, and promoting economic development. Consequently, individual transit agencies can vary widely in their relative emphases on social, economic, and other goals. Collectively, urban transit systems profoundly influence the U.S. economy and society at large, moving more than 27 million passengers a day.[2]

The U.S. Department of Transportation's Federal Transit Administration (FTA) maintains the National Transit Database (NTD), a mandatory census of all but the smallest transit agencies. The NTD provides an accurate data series of passenger miles traveled, representing industry output, an underlying measure of labor productivity. By using these data, BLS has developed a single national industry-level time series measure of labor productivity for urban transit systems that begins in 2007.

This article studies the efficiency with which industry workers provide transportation services. First, we present background on the role of the urban transit industry in the U.S. economy and society. Second, we define the characteristics of establishments that compose the industry. Third, we look at how labor productivity in the urban transit systems industry has been measured in the past and how we think it should be measured going forward. In particular, we focus on the nature of output in urban transit systems. Fourth, we describe the data sources and techniques used to construct the labor productivity measure, and follow with an analysis of the results. The article concludes with a look at the state of the industry in 2017. Two appendixes review further research relevant to the study of urban transit systems.

The importance of urban transit systems

The U.S. urban transit systems industry employed 405,000 workers in 2015. Of these, approximately 193,000 (48 percent) worked in the public sector.[3] In 2015, employment in urban transit systems was greater than in rail transportation (about 241,000) but less than in air transportation (about 435,000). Revenues for all forms of public transit totaled $62.8 billion in 2015. Only 38 percent of these funds came from passenger fares and related fees, while 62 percent came from local, state, and federal subsidies.[4] It is important to examine how effectively these resources are being used to provide public services.

A recent report by the Transportation Research Board (of the National Academy of Sciences) for the FTA listed "four primary roles of transit that can be documented and communicated:

1. Transit as a source of transportation efficiency improvement that also extends the effective capacity and service areas for existing road, rail, and aviation systems;
2. Transit as a public service that provides access to job, education, and health care opportunities for dependent populations;
3. Transit as a strategic planning and development tool that affects the spatial and economic development of metropolitan areas and rural regions; and
4. Transit agency activities as a generator of jobs and income."[5]

Much of the literature on the economic impact of urban transit focuses on how it can facilitate agglomeration economies[6] in dense, highly productive large cities. Because skilled workers tend to concentrate in small urban areas where knowledge spillovers and other advantages exist (such as in midtown or downtown Manhattan), an excess of private-car commuters congests traffic. Thus, many observers believe that mass transit systems are indispensable to a modern economy that is dominated by advanced services. However, since the mid-20th century, less skilled workers have been the most reliant on urban transit systems. (See appendix A.)

Other scholars have associated the expansion of urban transit systems with broad social and environmental goals. These goals, like labor market impacts, may be seen as indicative of society's overall willingness to pay for urban transit services. For example, one researcher listed pollution abatement and reduced energy consumption among the transit impact measures for a hypothetical performance scorecard.[7] Other scholars have found that urban transit promotes walking among commuters (with associated health benefits)[8] and reduces traffic congestion in large cities.[9]

Some evidence suggests that political support for transit funding in the United States is often greater than actual usage. Consequently, the social and ecological benefits of urban transit systems may not be optimally realized, given the hefty cost of public investment. One paper noted that "transit voters" (people who support tax increases to fund transit) are "more likely to live in and own detached single-family homes (which often implies low residential densities that inhibit transit service) . . . are more affluent, and have more choices than transit riders."[10] Another paper, similarly, observed that the priorities of prosperous suburban voters frequently crowd out the more tangible needs of the transit-dependent population, which is predominantly urban and lower income. The urban population tends to commute to downtowns by "express bus and rail transit," while those in the lower income group are more likely to ride city buses.[11] Rail is particularly attractive to affluent voters (who are less likely to commute by urban transit) because of "such characteristics as higher vehicle speeds and greater passenger comfort, and because it involves conspicuous infrastructure like stations and track."[12]

This disconnect between the needs of transit voters and transit riders obscures the relationship between public funding and ridership, a key reason our measure of output for this industry is not mainly based on revenues. Nonetheless, we believe that public funding, along with fares and other user fees, accurately represents society's overall willingness to pay for transit services. (See the "What is the output of urban transit systems?" section for more information on our use of expense share weights in output measurement.)

Industry definition

Under the North American Industry Classification System (NAICS), establishments must meet four criteria to be classified as urban transit systems (NAICS 4851). First, their primary activity must be the transportation of the general public from an origin to a destination. This excludes school buses, employee shuttles, and tourism vehicles. Second, the transportation service must be on a fixed route and a regular schedule. This excludes demand response systems,[13] vanpools, taxis, and ride-hailing services such as Uber or Lyft. Third, operations must be landbased, which excludes ferry boats. Finally, the scope of urban transit systems is limited to a single metropolitan area[14] and its adjacent nonurban areas. This excludes long-distance rail and bus services, as well as some rural bus systems.

Following these criteria, our measures of labor productivity in urban transit systems include the transit modes identified in table 1.

Table 1. Urban transit systems modes of transit, passenger miles (in thousands), 2015

Mode of transit	Description	Passenger miles

See footnotes at end of table.

Table 1. Urban transit systems modes of transit, passenger miles (in thousands), 2015

Mode of transit	Description	Passenger miles
Bus	Rubber-tired passenger vehicles, with fixed routes and schedules, operating on roadways.	18,675,215
Heavy rail	Electric railway with the capacity for a heavy volume of traffic. Characterized by high-speed passenger rail cars and exclusive rights-of-way.	18,283,014
Commuter rail	Electric or diesel propelled railway for urban passenger train service consisting of local short distance travel between a central city and adjacent suburbs.	11,687,418
Light rail	Electric railway with a light volume traffic capacity. Characterized by passenger rail cars operating singly (or in short trains) on fixed rails in shared or exclusive rights-of-way.	2,427,365
Commuter bus	Fixed-route bus systems that primarily connect outlying areas with a central city.	2,371,669
Bus rapid transit	Bus mode operating in an exclusive right-of-way with defined stations.	156,094
Trolleybus	Electric rubber-tired passenger vehicles, manually operating singly on city streets. Vehicles are propelled by a motor drawing current through overhead wires.	146,218
Street car rail	Rail transit systems operating entire routes predominantly on streets in mixed traffic.	104,905
Hybrid rail	Rail system primarily operating routes on the national system of railroads, but typically operating light rail-type vehicles as diesel multiple-unit trains.	94,653
Cable car	Electric railway with individually controlled transit vehicles attached to a moving cable located below the street.	8,575
Inclined plane	A railway, with exclusive right-of-way on steep slopes, operating powerless vehicles propelled by moving cables.	512

Source: National Transit Database.

Monorails, automated guideways, and aerial trams are not included in our measures because of a lack of consistent annual data. These three modes together accounted for less than one-tenth of 1 percent of total passenger miles traveled in 2015. Therefore, their exclusion has little effect on the output measure.

What is the output of urban transit systems?

As previously discussed, labor productivity describes the relationship of the output of an industry to the worker hours used to produce that output. In order to calculate industry productivity, we require a precise definition of the output of that industry. It is important that output be defined and measured independent of worker hours, otherwise the resulting productivity series would be inherently static. For urban transit systems, various output concepts have been implemented in prior productivity research. These can be summarized as either demand-side or supply-side output concepts.

A supply-side output concept measures the amount of service that is made available, regardless of how much is actually consumed. Two such concepts frequently used for passenger transportation are vehicle hours in service and available seat miles (or vehicle miles.) These measures are attractive from the point of view of system operators because they can account for how efficiently funds and labor are being translated into services offered.

While useful in some contexts, supply-side output measurement can lead to a distorted picture of productivity. For example, an outside observer would likely consider a bus full of passengers to be producing more output than an empty bus. However, a measure of output based on vehicle hours in service would count them the same. For this reason, BLS productivity measures for transportation industries generally favor demand-side output measurement. Demand-side output measures the volume of services being consumed, as opposed to the volume offered. The two predominant demand-side output concepts for urban transit systems are passenger trips and passenger miles. (See the "Prior studies of transit output and productivity" section for examples of both metrics.) Basing output on total passenger miles, rather than passenger trips, offers the advantage of accounting for trip length. A passenger taking a train trip from one end of the line to the other represents a greater quantity of service than a passenger traveling a single stop.

Our measure of urban transit systems output includes many different modes of transit, as listed in table 1, raising the following question: how should we aggregate passenger miles for different modes of transit? To answer this question, we must first decide whether the services provided by different forms of transit are heterogeneous. One could argue that the service provided by any transit system is simply the transportation of passengers from point A to point B. In that case, output for the industry as a whole is simply the quantity of total passenger miles produced by all transit systems. In other words, the mode of transportation is irrelevant. In reality, we understand that there are other aspects of urban transit—including convenience, comfort, reliability, and speed—that differentiate modes of transit.

Since modes of transit are indeed heterogeneous, we need a method for weighting their respective services. The standard method used to aggregate heterogeneous goods and services is value-share weighting (where value is calculated as price × quantity). In a competitive, market-based industry, prices are set according to consumers' willingness to pay for goods and services. Both the price and quantity of a service reflect its relative importance to consumers. Value-share weighting is an appropriate method of aggregation for many private goods and services because relative value is directly proportionate to relative consumer demand.

There are important theoretical impediments to using value-share weighting to aggregate output for urban transit systems. Because this is not a market-based industry, prices do not equal marginal costs for transit providers nor marginal utility to consumers. Transit agency revenue comes from both public tax dollars (and other subsidies) and rider fees; the amount of the former influences the price set for the latter. Many systems also provide uncompensated services (e.g., free or reduced fares for seniors or students). Therefore, prices and revenues are not directly related to consumer demand, as they are in other industries. Consequently, we employ a metric other than value share for purposes of weighting.

Even though system revenues are an unsuitable weighting metric for urban transit systems, the idea that willingness to pay determines relative importance is still the guiding principle of our model. If we consider urban transit as a public good, then the expenses incurred by each system can be thought of as the public's *collective* willingness to pay. When deciding whether to build and operate two different types of transit systems (bus versus light rail, for example), one will usually require greater expense than the other. In order for the more expensive mode to be chosen, we can assume that it provides some greater utility to the public beyond the miles traveled.[15] Thus, we conclude the modes that cost more to build and operate must be of higher relative importance to the public. Accordingly, we use an output-weighting system based on the total *expenses* of the various urban transit systems.[16]

Prior studies of transit output and productivity

Several other statistical agencies have grappled with the dilemma of how to measure the output component of urban transit systems productivity measures. Labor productivity ("output per hour worked") is measured as a ratio of an industry's output to the labor input used in the production of that output. (See the "Index of hours worked" section for more information on the labor measures.) Other measures of efficiency and effectiveness resemble labor productivity, but these concepts should not be confused.[17] While other agencies have attempted to include other factors of production (inputs) into their calculations for the urban transit systems industry, such as capital, the BLS productivity program aims to first establish measures of labor productivity for urban transit. A future expansion of the project may include a measure of multifactor productivity (MFP) as a ratio of output to the combined inputs of labor, capital, and intermediate purchases.

It is also important to note that while studies of productivity at the firm (i.e., agency) level offer a compelling field of microeconomic research, this is not the focus of our study. (A survey of representative research is available in appendix B.) Rather, in this section, we endeavor to show how precedent has informed our selection of output methodology and data for urban transit systems.

Supply side or demand side?

Two studies of productivity in U.S. urban transit systems were included in John W. Kendrick's extensive reviews of U.S. industry productivity trends for the National Bureau of Economic Research (NBER).[18] Kendrick's output series of "local transit" bus and rail services was based on revenue passengers carried but excluded government operators. Although the industry shift to the public sector was well underway in the post-World War II era, Kendrick's demand-side output series was consistent with his other transportation series, such as line-haul railroads and air transportation.

However, a later report by John R. Meyer and Jose A. Gómez-Ibañez for NBER, which Kendrick himself edited, provided a compelling summary of the challenges in reconciling demand-side and supply-side measures of transit output.[19] Meyer and Gómez-Ibañez acknowledged that measuring output by passenger miles, if the data were available then, would capture the increase in trip lengths that presumably occurred in the post-World War II era.[20] However, they noted that basing an output measure on vehicle miles would more directly account for certain quality improvements, such as maintaining service frequency at an adequate level to avoid crowding.[21] In addition, the quantity of vehicle miles produced by transit agencies reflects political and social considerations mandating service with lower passenger utilization, for example, the need to provide service to less densely populated communities or during evenings and weekends.[22] Accordingly, output indexes based on vehicle miles and passenger miles (or passenger trips) may be seen, respectively, as upper and lower bounds of output estimates.[23] As a result, Meyer and Gómez-Ibañez presented their output and productivity results on both supply-side and demand-side bases.

A study of transit agencies' MFP by the Productivity Commission of the Australian Government[24] and a BLS study of industry labor productivity[25] applied this two-pronged approach in their output measures. Both studies reported separate output measures based on demand-side (passenger kilometers or unlinked passenger trips) and supply-side (seat kilometers or vehicle revenue miles[26]) concepts of transit system output.

Passenger trips or passenger miles?

Once theoretical concerns are addressed, we must determine whether the desired data are available. Kendrick's output measurements for line-haul railroads and air transportation were similar to the passenger components of BLS current series for these industries in that he used revenue passenger miles as the basis of the indexes.[27] However, Kendrick's studies of productivity in private-sector urban transit systems measured output in terms of revenue passengers carried, implying the lack of sufficient passenger miles data.[28] These missing data were also the reason that BLS used unlinked passenger trips in the 1998 government productivity report.

A study of productivity in Canada's transportation industries encountered the same roadblock. In a 2009 study, The Conference Board of Canada measured the output of line-haul passenger rail and air transportation, using passenger kilometers.[29] Urban transit systems were measured by the number of passengers carried because the length of passenger trips was unavailable.[30] The study reported a substantial decline in public transit productivity over the 1986–2006 timeframe.[31] However, the study's authors acknowledged that their productivity measure did not capture the effect of changing average trip lengths, which probably increased "due to urban sprawl and the rising proportion of [long-distance] commuter trips."[32] Thus, the reported productivity decline was likely overstated.[33] This illustrates, once again, the aforementioned observation that the efforts of transit agencies to adapt to changing patterns of urban settlement and commuting are better accounted for by measuring output as distance traveled, rather than as number of boardings.

Data sources

The National Transit Database (NTD) is the primary source of physical quantity output data for our urban[34] transit systems measure. The NTD is the primary government source for information and statistics on the transit systems of the United States. Over 750 transit providers in urbanized areas currently report to the NTD through the Internet-based reporting system.***[35]***

NTD classifies transit systems as either directly operated (DO) or purchased transportation (PT). DO service is provided by a transit agency, using their employees to supply the necessary labor to operate the revenue vehicles. PT service is provided by a public or private provider based on a written contract. In 2014, DO systems nationwide accounted for approximately 58,000 vehicles operated in maximum service, while PT systems reported about 11,000.[36] Reporting of services (such as vehicle and passenger miles and trips) and expenses is mandatory for both DO and, in most cases, PT services.

NTD's stringent reporting requirements make it possible to build a labor productivity measure based on accurate and reliable data. However, in order to mitigate the burdensome nature of data collection, the NTD permits PT and small systems (i.e., "reduced reporters") to report a reduced amount of data elements. To account for uncollected NTD data from reduced reporters and PT services, we utilize supplementary data from the American Public Transportation Association (APTA) fact book. The APTA fact book supplements NTD data with other sources to represent the total activity of all transit agencies.[37]

Table 2 and the following sections show how data elements from both the NTD and APTA are used to construct indexes of output and hours worked for urban transit systems.

Table 2. Data elements for urban transit systems output and hours worked, descriptions and data sources

Data element	Use	Data source
Output		
Passenger miles by mode	Basis of the quantity measure for output	National Transit Database
Unlinked passenger trips by mode	Used to estimate reduced reporter passenger miles	National Transit Database

See footnotes at end of table.

Table 2. Data elements for urban transit systems output and hours worked, descriptions and data sources

Data element	Use	Data source
Operating expenses by mode	Contribute to weights for aggregating passenger miles	National Transit Database
Capital expenses by mode	Contribute to weights for aggregating passenger miles	American Public Transportation Association (2007–14)
		National Transit Database (2015 to present)
Hours worked		
Total employment	Basis of the measure of labor input	American Public Transportation Association
Directly operated transit systems employment by mode	Used to estimate employment for in-scope modes of transit	National Transit Database
Directly operated transit systems hours worked by mode	Applied to total employment yields measure of hours worked	National Transit Database

Source: U.S. Bureau of Labor Statistics.

Index of transit system output

The volume of services provided by urban transit systems is expressed as an annual index of output (i.e., the percent change in the time series index corresponds to the change in volume of service). This index is based on the total number of passenger miles traveled per year. Passenger miles are measured for each mode of transportation and then aggregated using weights based on total expense shares (which include both capital and operating expenses). Each element of this process is discussed below.

Transit agencies report unlinked passenger trips and passenger miles traveled to the NTD. Transit agencies must collect the actual number of passengers as they board a vehicle, yielding the number of trips. Passenger miles are generally determined by choosing a random sampling of passengers and tracking their miles traveled.[38] Transit agencies impute total passenger miles traveled by combining the sampled miles with counts of unlinked passenger trips.

The NTD requires transit agencies with more than 30 vehicles operated in maximum service across all modes or that provide fixed-guideway service or high-intensity bus service[39] to report passenger miles traveled.[40] These agencies are referred to as full reporters. Other agencies are classified as reduced reporters and are not required to report passenger miles traveled.[41] Because reduced reporters do report passenger trips, we impute the associated passenger miles by using the passenger miles per trip ratio that full reporters provide for each mode, as equation (1) shows:

$$\sum \text{reduced reporter PMT}_m = \sum \text{reduced reporter UPT}_m \left(\frac{\sum \text{full reporter PMT}_m}{\sum \text{full reporter UPT}_m}\right), (1)$$

where m = detailed transit mode,

PMT = passenger miles traveled, and

UPT = unlinked passenger trips.

The annual totals of passenger miles by mode are aggregated into an overall industry output index with their respective shares of total system expenses as weights. Total expenses include both operating and capital expenses. Capital expenses are defined as revenue outlays for the purchase of equipment that has a useful service life of more than 1 year. All other expenses associated with the standard operation of a transit agency are classified as operating expenses. Broadly speaking, rail modes of transit will allot a higher proportion of capital expenses to operating expenses, as they must pay for infrastructure elements not inherent to roadway travel.

Characteristics of reduced reporters

Because of the variety of urban settings and operating characteristics of reduced reporter transit systems, we are unable to determine a single way of estimating average passenger-trip miles by mode, other than to assume similarity between reduced reporters and full reporters. Reduced reporters, though they have fewer vehicles in their active fleets than full reporters, are not limited to smaller urban areas and exclude rural areas. (Rural reporters are classified separately and are not included in our measures.) For example, the rather heterogeneous reduced reporters list in 2015 includes bus agencies within large urban areas (e.g., various suburbs and satellite cities in New Jersey that are within the New York City urban area), as well as medium and small urban areas. In terms of transit modes within our scope, these agencies provide both city buses and commuter buses. The list of reduced reporters includes numerous tribal agencies (such as the Menominee Indian Tribe of Wisconsin), a few universities (University of Arkansas is the largest such system), an Area Agency on Aging (in Aiken, South Carolina), several private non- and for-profit corporations, and many local government authorities.

Data for operating expenses are drawn from the NTD. Figures for capital expenses are based on APTA data prior to 2015 and NTD data from 2015 onward.[42] Data are aggregated using the following Törnqvist formula:[43]

$$\frac{Q_t}{Q_{t-1}} = \exp\left[\sum_{m=1}^{n} w_m \left(\ln \frac{\mathrm{PMT}_{m,t}}{\mathrm{PMT}_{m,t-1}}\right)\right], \quad (2)$$

where $\frac{Q_t}{Q_{t-1}}$ = the ratio of urban transit system output in year *t* to year *t*-1,

n = the number of modes of transit,

$\ln \frac{PMT_{m,t}}{PMT_{m,t-1}}$ = the natural logarithm of the ratio of passenger miles traveled in mode *m* in the current year to passenger miles traveled in the previous year, and

w_m = the average share of total expenses for mode *m*, which is calculated as shown in equation (3):

$$w_m = \frac{\left(\frac{\mathrm{OE}_m + \mathrm{CE}_m}{\sum_m (\mathrm{OE}_m + \mathrm{CE}_m)}\right)_t + \left(\frac{\mathrm{OE}_m + \mathrm{CE}_m}{\sum_m (\mathrm{OE}_m + \mathrm{CE}_m)}\right)_{t-1}}{2}, \quad (3)$$

where

OE = annual operating expenses and

CE = annual capital expenses.

Index of hours worked

To construct an index of hours worked, we use both a count of employees and a measure of their average yearly work hours. Employment data are obtained from APTA, while average hours come from the NTD.[44]

As described above, NTD classifies transit systems as either DO or PT. However, NTD reports employment and hours for DO transit systems only, while APTA provides data for both DO and PT.

The APTA fact book reports the total number of workers for all modes of urban transit. Because some of these modes are not in scope for our measure, we adjust these employment totals based on a ratio from the NTD employment data. The NTD reports employee work hours and employee counts, by mode. For employee counts, we create annual ratios for in-scope modes to totals by removing Alaska Railroad, demand response, ferry boat, vanpool, and monorails/automated guideways. These ratios are applied to the worker totals from APTA to obtain the total number of employees for urban transit systems.

Recall that we must combine data on employment with information on average hours worked. For productivity measurement, work hours are preferred to paid hours because they exclude time off, such as holiday leave and sick time. Work hours also better represent the effective contribution of labor into the production process. However, APTA does not report hours worked. Fortunately, the NTD reports total employee work hours by mode annually. We add up the total number of hours and employees for in-scope transit modes by year. Dividing the total hours by total employees yields average yearly hours.

Average hours from NTD are multiplied by total employment from APTA to determine total hours worked in urban transit systems, as expressed in equations (4) and (5):

$$\text{Total employment} = \text{APTA total employment}\left(\frac{\text{NTD in} - \text{scope total employment}}{\text{NTD total emploment}}\right), \quad (4)$$

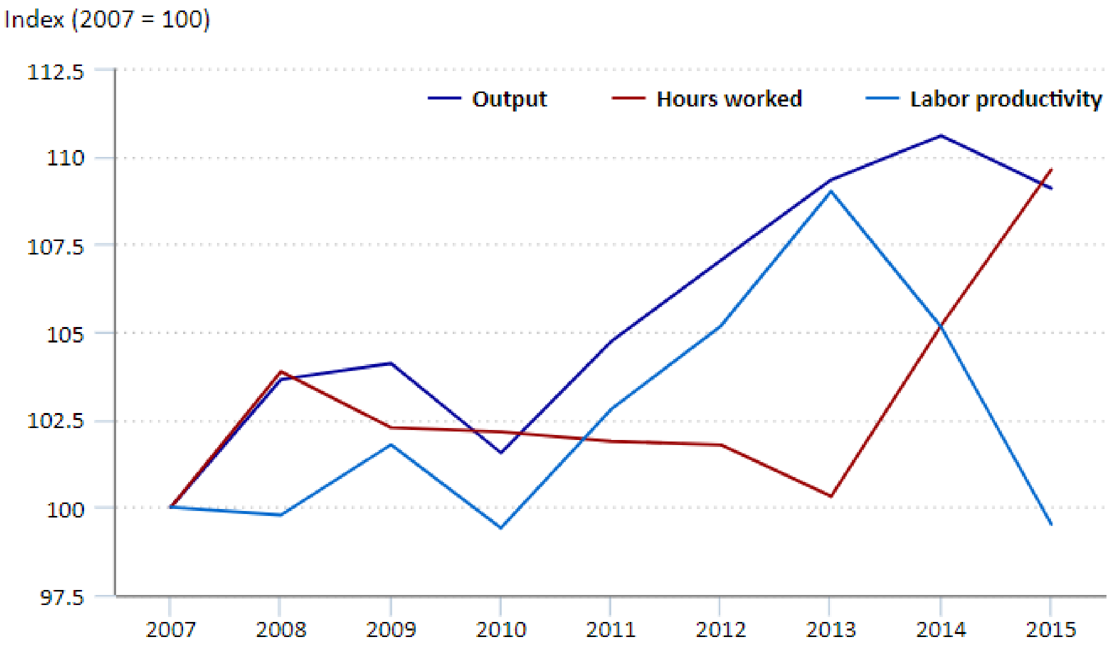
$$\text{Total hours worked} = \text{Total employment}\left(\frac{\text{NTD in} - \text{scope total hours worked}}{\text{NTD in} - \text{scope total employment}}\right). \quad (5)$$

When calculating labor productivity, the index of total hours worked is the denominator.

Labor productivity and other results

Labor productivity is calculated by dividing the index of urban transit systems output by an index of hours worked. Labor productivity growth in urban transit systems was modestly positive from 2007 to 2013, growing by an average annual rate of 1.4 percent. Over that period, average annual growth of output outpaced that of hours worked, 1.5 percent to 0.1 percent (see figure 1.) However, between 2013 and 2015, the trends in output and hours worked reversed, with output declining by an average of 0.1 percent while hours worked grew by an annual average of 4.5 percent. Consequently, by 2015, labor productivity for urban transit systems had fallen below its starting point in 2007.

Figure 1. Urban transit systems indexes of labor productivity, output, and hours worked, 2007–15



Click legend items to change data display. Hover over chart to view data.
Source: U.S. Bureau of Labor Statistics.

Surface rail, which includes light rail and streetcar, experienced the fastest growth in passenger miles from 2007 to 2015. Passengers traveled 1.9 billion miles on surface rail in 2007. By 2015, this had grown to 2.5 billion miles, an average annual increase of 3.5 percent. Several new light rail systems began operating during this period. A few of the larger ones were the Charlotte LYNX Blue Line, the Seattle Central Link, the Norfolk Tide, and the Phoenix Valley Metro Rail. Existing systems saw significant growth in passenger miles. For example, passenger miles grew on Denver's NTD light rail by an average annual rate of 5.4 percent and on Los Angeles's Metro Rail light rail system by 3.6 percent. Table 3 shows the passenger miles of the other large modes (cable car and inclined plane are not shown) of transit from 2007 through 2015.

Table 3. Urban transit systems by major mode, passenger miles (in millions), 2007–15

Year	Total bus[(1)]	Regional rail[(2)]	Heavy rail	Surface rail[(3)]
2007	20,424	11,137	16,138	1,930
2008	21,204	11,032	16,850	2,081
2009	21,105	11,129	16,805	2,196
2010	20,574	10,774	16,407	2,173
2011	20,709	11,384	17,317	2,294
2012	20,424	11,194	17,516	2,415
2013	21,553	11,819	18,005	2,481
2014	21,732	11,691	18,339	2,583
2015	21,203	11,782	18,283	2,532

See footnotes at end of table.

Table 3. Urban transit systems by major mode, passenger miles (in millions), 2007–15

Year	Total bus[(1)]	Regional rail[(2)]	Heavy rail	Surface rail[(3)]
Average rate of change, 2007–15	0.5%	0.7%	1.6%	3.5%

Notes:

(1) This includes bus, commuter bus, and bus rapid transit.

(2) This includes commuter rail and hybrid rail.

(3) This includes light rail and streetcar.

Source: U.S. Bureau of Labor Statistics.

Components of output growth, 2007–15

Growth in any of the following inputs can increase passenger miles traveled: average passenger trip length,[45] average number of passengers carried per hour,[46] or total number of vehicle hours (an aggregate measure of the volume of service provided).[47] These metrics are unique and can move in different directions. Passenger miles traveled can be seen as a multiple of these three vertically related factors, as shown in equations (6) and (7), which are alternative ways of expressing a single basic identity:

$$\text{PMT} = \text{Average passenger trip length} * \text{Passengers per hour} * \text{Annual vehicle hours}, \quad (6)$$

$$\text{PMT} = \left(\frac{\text{PMT}}{\text{Passenger trips}}\right) * \left(\frac{\text{Passenger trips}}{\text{Vehicle hours}}\right) * \text{Vehicle hours}. \quad (7)$$

Table 4 shows how these metrics change for the major modes of transit over the period studied.

Table 4. Urban transit systems by major mode, output factors, average annual percent change, 2007–15

Year	Total bus[(1)]	Regional rail[(2)]	Heavy rail	Surface rail[(3)]
Total passenger miles traveled	0.5	0.7	1.6	3.5
Average passenger trip length	0.9	-0.3	0.2	0.5
Passengers per hour	-0.8	-0.6	0.7	-1.1
Annual vehicle hours	0.4	1.7	0.6	4.1

Notes:

(1) This includes bus, commuter bus, and bus rapid transit.

(2) This includes commuter rail and hybrid rail.

(3) This includes light rail and streetcar.

Source: U.S. Bureau of Labor Statistics.

The data reveal interesting differences in how the major modes achieved their respective growth in passenger miles. As table 4 shows, the annual growth for surface rail output (3.5 percent), though rapid, did not keep pace with the expansion of vehicle hours (4.1 percent). This implies that the average fullness of vehicles in service, as measured by the combined effects of the frequency and duration of passenger trips, was negative. Regional rail shows a similar trend: vehicle hours grew because of increases in service frequency, new system openings, and route expansions. Most of the major established regional rail systems recorded increased service levels. Among them, New York's Long Island Rail Road and Pennsylvania's SEPTA Regional Rail, which increased vehicle hours by 3.3 percent and 4.6 percent, respectively. In addition, new systems opened, including the FrontRunner in Utah, the Rail Runner in New Mexico, the WES in Oregon, and the Northstar Line in Minnesota. As surface and regional rail modes increased the quantity of vehicles in service, the average number of passengers per hour declined modestly. This could be because the new systems have lower utilization rates than established systems in cities that urbanized early on, such as New York City and Chicago, where commuting patterns have long developed around transit use.

In contrast to the other major modes, heavy rail recorded growth in each of the factors underlying passenger miles traveled. Heavy rail was the only major mode to have growth in passengers per hour from 2007 to 2015. The New York City subway system[48] accounts for, by far, the largest portion of the heavy rail mode, with more passenger miles and passenger trips than all other urban heavy rail systems combined. Thus, this system, which increased ridership at roughly the same rate as the nation's other heavy rail systems, also contributed to the majority of heavy rail's growth in passenger miles and passenger trips. However, increasing passengers per hour is seen not just in New York, but in three out of the next four largest systems—Chicago, Boston, and San Francisco. One cause of this trend is likely the increasing population of the dense downtown areas in these cities,[49] where mass transit is an important option for mobility.

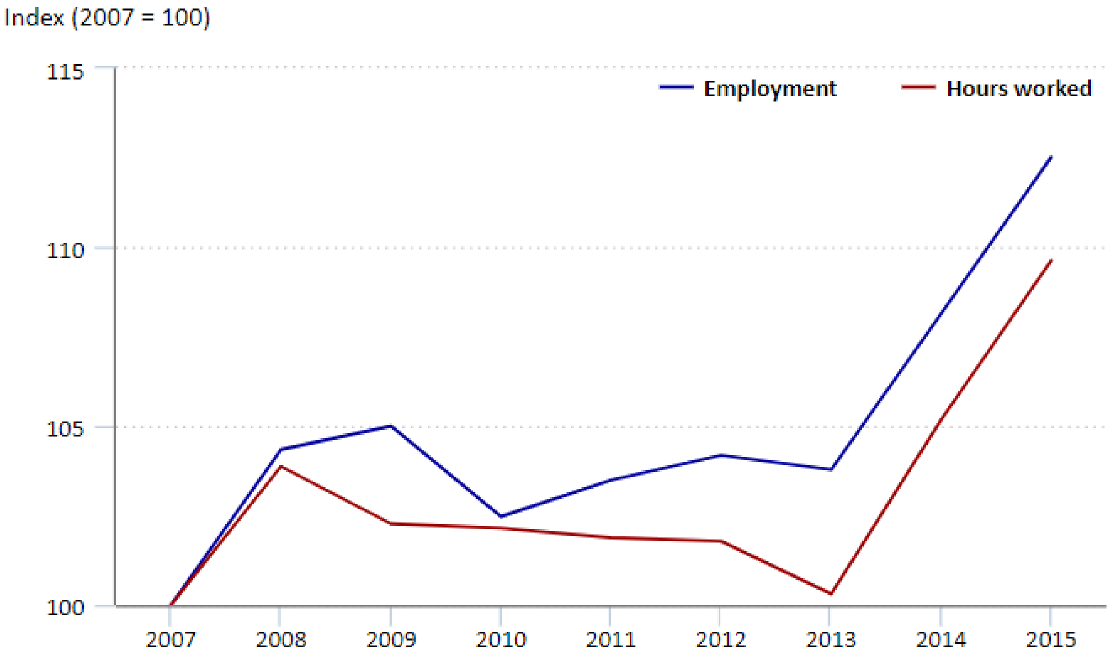
Notably, every major transit mode except for regional rail saw increasing average trip length from 2007 to 2015. The fastest growth rate was for buses, perhaps because of the expansion of commuter bus services during the timeframe.[50] As shown in table 1, buses accounted for the largest share of passenger miles traveled. Therefore, the increased average trip lengths of buses contributed heavily to output growth among transit systems as a whole.

Labor, 2007–15

NTD does not report total employment for PT transit systems. Therefore, precisely depicting total employment by mode is difficult. However, DO transit systems accounted for approximately 61 percent of industry employment in 2015. Bus systems (including commuter bus and bus rapid transit) make up the largest share of DO employment. Bus system employment decreased slightly over the period studied—from 154,100 in 2007 to 149,525 in 2015. Heavy rail is the next largest contributor to DO employment—up slightly from 54,900 in 2007 to 58,268 in 2015. DO employment in surface rail increased from 9,400 in 2007 to 12,829 in 2015.[51] Commuter rail employment was virtually unchanged over that period.

Employment in urban transit systems has grown slightly faster than hours worked (see figure 2). This indicates that workers are working fewer hours on average. NTD reports that average weekly hours for DO transit systems dropped from 36.7 in 2007 to 35.8 in 2015.

Figure 2. Urban transit systems indexes of employment and hours worked, 2007–15



Click legend items to change data display. Hover over chart to view data.
Source: U.S. Bureau of Labor Statistics.

Transit productivity in context

BLS currently publishes labor productivity measures for three other large transportation industries: air transportation, line-haul railroads, and truck transportation. Between 2007 and 2015, labor productivity in these three private industries increased,[52] in contrast to the decrease for urban transit systems. (See table 5.)

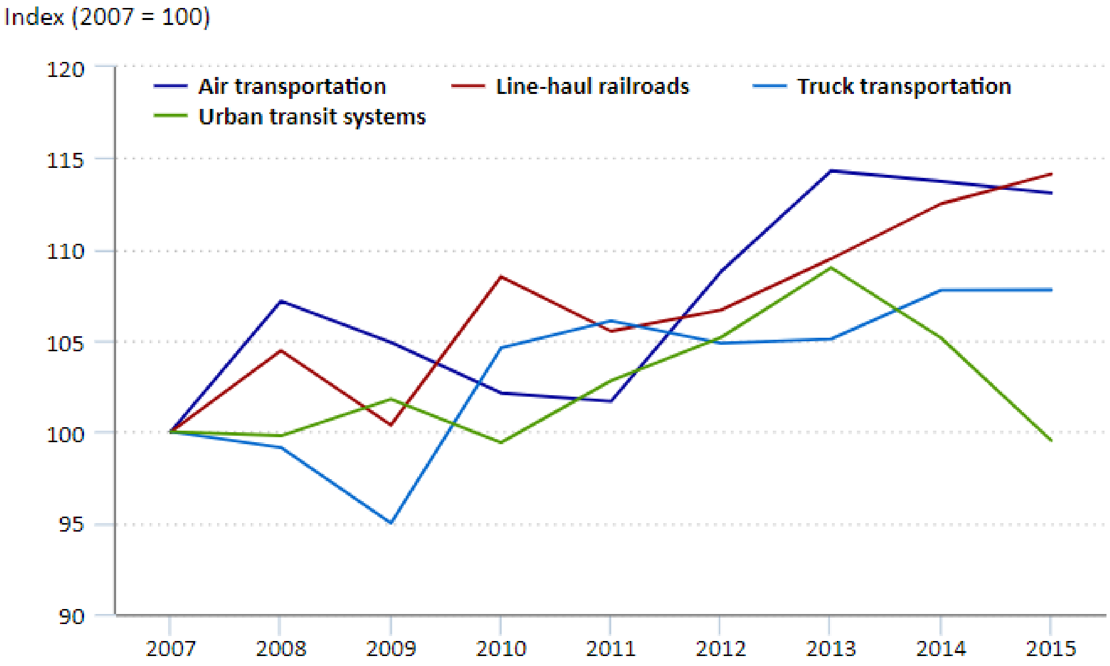
Table 5. Average annual percent growth in labor productivity, output, and hours worked for selected transportation industries, 2007–15

Index	Air transportation	Line-haul railroads	Truck transportation	Urban transit systems
Labor productivity	1.5	1.7	0.9	-0.1
Output	0.7	1.2	0.7	1.1
Hours worked	-0.8	-0.5	-0.2	1.2

Source: U.S. Bureau of Labor Statistics.

The annual indexes of labor productivity for these industries reveals an interesting trend. Labor productivity growth shows a similar pattern among the two freight-moving industries (truck transportation and line-haul railroads). Conversely, labor productivity growth in the two passenger-moving industries (air transportation[53] and urban transit systems) does not trend in an interrelated manner. (See figure 3.)

Figure 3. Labor productivity indexes, selected transportation industries, 2007–15

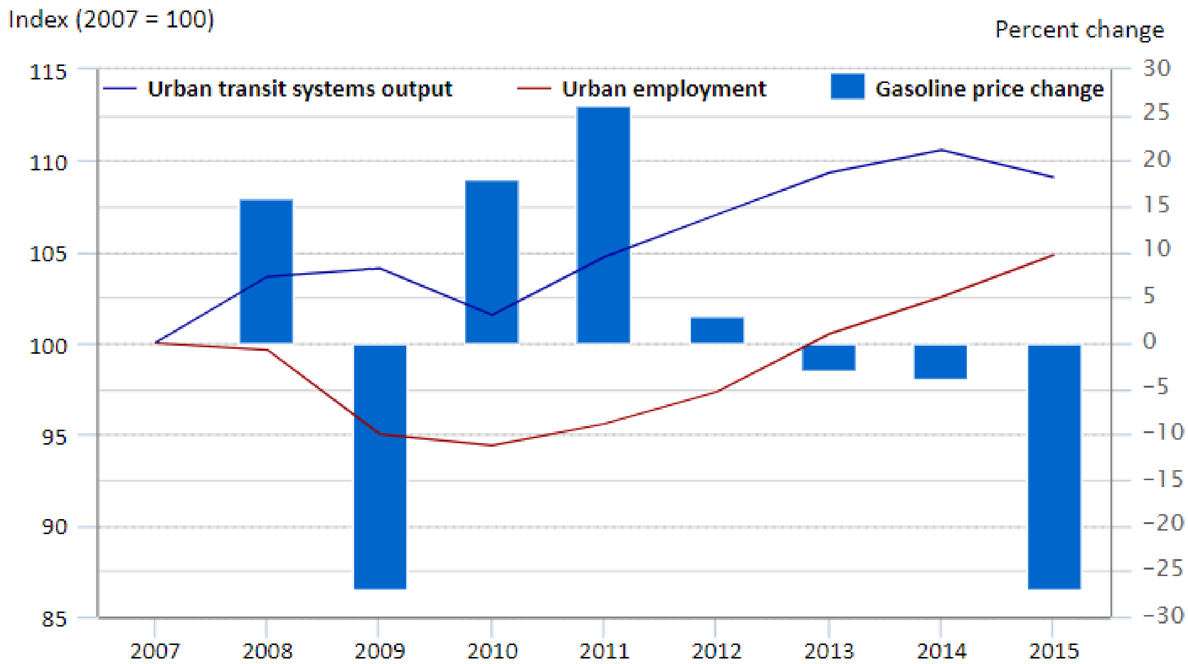


Click legend items to change data display. Hover over chart to view data.
Source: U.S. Bureau of Labor Statistics.

Broadly speaking, the labor productivity performance of the freight-moving industries appears to be closely associated with the state of the overall economy. Labor productivity in both industries dropped sharply during the Great Recession of 2007–09. During this time, general demand for transportation of goods and materials was depressed as economic activity was reduced overall. Since then, productivity growth has improved as the economy recovered.

National economic trends affect labor productivity in the passenger transportation industries as well. Notably, there is a positive relationship between labor market conditions and ridership of urban transit systems.[54] (Recall that commuting to work is the most important reason for riding transit.) However, the price of fuel also substantially affects the productivity of these industries. (See figure 4.)

Figure 4. Urban transit systems output index, urban employment index, and percent change in gasoline prices, 2007–15



Click legend items to change data display. Hover over chart to view data.
Source: U.S. Bureau of Labor Statistics, Office of Productivity and Technology, Quarterly Census of Employment and Wages, Consumer Price Index.

Figure 4 shows the relationship between urban transit system output and two contributing macroeconomic series—the price of gasoline and total urban employment. Both high gasoline prices and high levels of urban employment increase demand for urban transit services. For example, rising gasoline prices in 2011 (which continued through 2013) helped lead to faster growth in ridership of urban transit systems (3.1 percent) as the relative cost of driving grew. Similarly, as the urban labor market gained strength following the end of the Great Recession in 2009, urban transit system output followed suit.[55] Notably, urban transit system output declined in 2015, despite continued growth in urban employment. We suspect that the sharp drop in gasoline prices played a major role.

Transportation industries are sensitive to rapid changes in consumer demand. Broad external forces, such as changes in fuel prices or labor market conditions, motivate increased or decreased consumption of transportation services. As shown in figure 1, the hours worked in urban transit systems do not generally change at the same pace as the changes in output. In this way, transportation industry labor productivity tends to fluctuate with national economic conditions.

The present and future of urban transit systems

Ridership growth in urban transit systems has been steady and consistent. According to the APTA, ridership in all forms of public transportation "has increased by over a billion trips each of the past two decades."[56] New service has the potential to continue this growth. In 2017, new or expanded service in rail or bus rapid transit systems opened in 11 states. Eleven other states also either began or planned to begin new construction on new or expanded rail or bus rapid transit systems.[57]

A potential hindrance to transit growth is competition from ride-hailing services such as Uber and Lyft. A new study from the UC Davis Institute of Transportation Studies reports that users of ride-hailing services in large cities reduce their use of bus and light rail.[58] On the other hand, ride-hailing consumers were more likely to use commuter rail.[59]

Another concern is that growth in ridership depends on the continued reliability of urban transit systems. These systems require continuous capital investment in order to run at peak capacity. Funds for capital investment and upkeep are drawn from local, state, and federal governments and therefore compete with other priorities. According to the U.S. Department of Transportation's 2015 report to Congress on the status of the nation's transportation infrastructure, 31.4 percent of guideway elements of rail systems (track, ties, tunnels, etc.) are in poor condition.[60] This means that they have "seriously damaged components in need of immediate repair."[61] The consequences of infrastructure decay can already be seen in some places. For example, the Washington, DC area Metro has suffered decreased ridership, as track repair downtime has led to decreased system reliability.[62] Whether sufficient funds will be made available for transit systems to keep up with ridership demand is a question that remains open.

Conclusion

Well-functioning systems of public transportation are important catalysts for the growth of urban economies. Although the number of systems continues to increase, infrastructure decay in existing systems remains a serious threat. Ridership will continue to depend on the reliability of the systems themselves, as well as the supply of urban jobs and the cost of alternatives, such as ride-hailing services and private-vehicle ownership.

In order to study the efficiency with which urban transit systems deliver services, the BLS productivity program has developed a new index of labor productivity. BLS defines output in several transportation industries as the distance people or freight are carried. The definition of output for urban transit systems conforms to this precedent, as the number of passenger miles traveled serves as the basis of output for the industry. After growing from 2007 to 2013, labor productivity in urban transit systems fell for 2 consecutive years. This labor productivity measure is available on the BLS website and will be updated annually.

Appendix A. Urban transit and labor markets

The literature on the relationship between urban density and productivity, particularly in recent years, is deep. For example, Leo Sveikauskas found strong evidence of a positive association between urban population growth and productivity in the United States.[63] He found indications in the growth dynamics of the sampled cities that the direction of causality was from population growth to increasing productivity.[64] More recently, Rudiger Ahrend et al. demonstrated that a similar relationship exists across developed countries in the Organisation for Economic Co-operation and Development.[65] They attributed their findings, in part, to both the presence of more productive workers in large cities and features of large cities that make workers more productive.[66] Antonio Ciccone and Robert E. Hall found a stronger relationship, in the United States, between population density and productivity than between population size and productivity.[67] Furthermore, Ciccone and Hall's analysis determined that the direction of causality was largely from density to productivity.[68]

In recent years, several compelling explanations have been offered for the apparent relationship between urbanization and productivity. For example, Paul Krugman developed a spatially oriented model that emphasized the importance of minimizing the costs of transporting goods among manufacturers.[69] However, Edward L. Glaeser and Joshua D. Gottlieb noted that since cities today are more focused on the service economy, the importance of reducing transportation costs for manufacturers has declined.[70]

Other researchers have looked to labor markets to understand the relationship between urban density and productivity, such as in connecting employers to employees.[71] The role of transit systems in facilitating job matching is, at a minimum, highly suggestive: survey data indicate that commuting is the most important function of urban transit systems. Data from the Department of Transportation's National Household Transportation Survey (NHTS) and the American Public Transit Association's (APTA) meta-analysis of onboard passenger surveys indicate that anywhere from 33 percent to 59 percent of transit trips are for work-related purposes.[72] (APTA's analysis indicates that "school" and "shopping and dining" are the next most common purposes of transit use.[73]) Both the Department of Transportation and the Census Bureau have consistently estimated urban transit's share of commuting at about 5 percent of workers.[74]

Some scholars have attempted to measure the extent to which urban transit services increase access to jobs. Daniel G. Chatman and Robert B. Noland analyzed more than 300 U.S. metropolitan areas and observed that rising transit service levels have positively affected urban employment, wage growth, and output.[75] Most of these effects come through "redistribut[ing] employment" from metropolitan peripheries to dense urban centers.[76] Historically, as Glaeser et al. have shown, the high concentration of poverty in the central cities of many U.S. metropolitan areas is partly due to the greater dependency of low-income populations on public transit.[77] In a contemporary illustration of this phenomenon, Justin Tyndall examined the consequences of a temporary reduction of transit service in part of New York City caused by Hurricane Sandy.[78] Tyndall found a large negative effect on employment for transit dependent populations in the impacted neighborhoods.

Perhaps the most important way that urban transit affects labor markets is by encouraging the clustering of high-skilled research and service sector jobs. An expanding body of scholars—often drawing from Jane Jacobs'[79] writings on urban economic diversity or the human capital-driven economic growth models of Robert E. Lucas, Jr.[80] and Paul M. Romer[81]—have explored how the relationship between density and knowledge spillovers among skilled workers affects innovation and urban productivity gains.[82] A notable example of this is a study by Gerald Carlino et al., which found that high employment density is associated with increases in patents per capita, a measure of innovation.

If dense concentrations of knowledge workers benefit urban development, then one might hypothesize that mass transit systems help spread ideas and innovation. (Indeed, the share of transit commuting is notably higher, and growing, in very dense cities like New York and San Francisco[83] which have also demonstrated high productivity growth over the past 30 years.[84]) This would be especially true in transit-rich urban nodes with a lot of traffic congestion. Stuart S. Rosenthal and William C. Strange observed that a high density of workers can cause another type of spillover, counteracting the productivity-enhancing knowledge spillovers. "On the negative side," they wrote, "the spatial concentration of employment can increase congestion, lengthen commutes, and in so doing reduce labor productivity and wages, *ceteris paribus*."[85]

Patricia Melo et al. developed this idea further in a spatial analysis of the 50 largest U.S. metropolitan areas.[86] The authors determined that increasing the share of jobs within 20 minutes' access to commuters has a major positive effect on urban productivity.[87] This underscores the need to invest in "efficient transport networks."[88] While they did not break out the role of urban transit specifically, they noted that it is "likely to be important" in transit-dependent big cities.[89]

Appendix B. Transit productivity at the agency level

Labor productivity in the urban transit systems industry is measured as a ratio of passenger miles traveled to the hours worked in the industry. While this article aims to measure productivity using a single factor input, future analyses may benefit from a more detailed examination of technological change, capital intensity, and other measurable components of productivity growth. This section discusses academic research into firm- and passenger-level decisions that affect transit productivity.

As with most industries, many factors outside the agencies' control affect output and labor input (e.g., economic, labor relations, technological, sociocultural, political, geographical, or infrastructural). Transit agencies must adapt to these constraints in order to maximize efficiency and effectiveness of service.

Maximizing productivity in urban transit systems involves a wide array of stakeholders, missions, and constraints. Patrick Van Egmond et al. categorized factors affecting urban transit system performance—"critical success conditions" (CSCs)—as follows:[90]

- External CSCs are outside the control of the agencies, such as the size, density, and dispersion of the urban area population.
- Strategic CSCs include long-term political, regulatory, and urban planning considerations.
- Tactical CSCs encompass how agencies manage service contracts, subsidies, interactions with the private sector or other transportation modes, and other organizational matters.
- Operational CSCs refer to the immediate relationship between the agency and its customers, including how services are allocated (e.g., mode, frequency, and route) and marketed.

Policy and broad social trends are outside the scope of this article, but it is important to acknowledge that the productivity of the urban transit systems industry is contingent on these factors, perhaps more than most industries.[91] Since our focus in this section is on transit agency decisionmaking, we will be looking primarily at tactical and operational factors. In terms of tactical CSCs, Van Egmond et al. determined that "regulated or limited competition" and "moderate subsidies" could have positive effects, but "high subsidies" could be counterproductive.[92] Regarding operational CSCs, they concluded that integrated, multimodal transit systems yielded positive returns.[93]

One way transit agencies can attempt to maximize passenger ridership while constraining costs is by anticipating passenger demand when they set fares and allocate services, then observing how passengers respond. Studies of transit elasticities of demand make it possible to examine the potential impact of these behaviors. Brian D. Taylor et al., in a cross-sectional study of 265 U.S. urbanized areas, credited most of the variation in transit ridership to external factors: the geographic, economic, demographic, and nontransit commuting characteristics of the cities.[94] However, Taylor et al. estimated that about 26 percent of the variation in per capita transit ridership was because of differences in service frequency and fare levels between the cities' transit systems.[95]

It is important to note that aggregate elasticities of demand mask the complexity of riders with different sensitivities. The Transportation Research Board (TRB) conducted a meta-analysis of numerous North American and European studies on the elasticity of transit ridership with regard to price.[96] The TRB found that the elasticities varied considerably by transit mode, type of fare, trip purpose, and customer characteristics—in addition to city characteristics.[97] Another TRB metastudy, this one examining U.S., European, and Australian agencies, found that elasticity of ridership with respect to service frequency depended on the factors listed above, plus interaction effects with prices.[98] Todd Litman completed a meta-analysis of a different set of transit service and price elasticity studies in the United States, Europe, and Australia.[99] The results, as in the TRB studies, differed depending on the type of user (transit-dependent riders versus discretionary riders), type of trip (noncommuters/off-peak travel versus commuters/rush hour), type of price change (fares, parking, effective price after quality adjustment), direction of price change (positive or negative), urban form,[100] and transit mode.[101] In summary, Litman's results indicated that short-term transit ridership fell around 0.2–0.5 percent for every 1.0 percent increase in fares. (The magnitude of this elasticity increases over time.[102]) Ridership increased 0.5–0.7 percent for every 1.0 percent increase in the level and quality of service.[103]

Some scholars have examined transit agency performance from a total factor productivity (TFP)[104] perspective to measure how technology and other inputs affect output. Typically, these studies observe TFP at the firm (i.e., agency) level, determining causal impacts on TFP through regression analyses. While BLS measures industry productivity as a time series index rather than as a cross-section at a given point in time, cross-sectional analyses can be helpful for understanding how the dynamics of individual transit agencies and transit modes affect the industry-level trends. An ambitious cross-sectional study by Pierre Wunsch looked at productivity and cost efficiency for 178 urban transit systems across 12 European countries.[105] The study was multimodal, assessing agencies that provided heavy rail, light rail and streetcar, and bus systems. Wunsch attempted to standardize measures of vehicle capacity across modes and systems for output data, while using labor, other operating costs, and capital expenditures for input data.[106] Wunsch determined that British systems fared particularly well as a result of recent deregulation efforts.[107] Other factors with a positive outcome on productivity included high traffic density (saturating the route with frequent vehicles, rather than over-expanding the network), high-capacity vehicles (but not streetcars), and high traffic speeds (though this is to a large extent out of the agencies' control).[108]

Many studies have built on a common theoretical framework since Rolf Färe et al. that uses a Malmquist index to calculate TFP, then decomposes the productivity growth into efficiency change and technical change.[109] Technical efficiency (i.e., catching up to the frontier) can be defined as the ratio of what is produced to what is possible to produce with a given set of inputs (e.g., labor, capital). Technical change (i.e., growth of technology) is what shifts the production possibility frontier further out. Increasingly, efficiency measures have been decomposed further to account for scale efficiencies. Under an assumption of variable returns to scale, a firm may be technically efficient for its mix of inputs, but can still increase productivity by increasing or decreasing the size of the input mix. Some scholars of productivity and efficiency measurement break out allocative efficiency (producing with an efficient mix of outputs and prices) and structural efficiency (such as accounting for congestion effects, in which additional inputs have a negative result).

Bruno De Borger et al., in a metastudy of frontier analyses, attributed much of the variation in technical efficiency among transit systems to quality of management and external factors such as the regulatory environment.[110] DeBorger et al. observed that productivity improvements in transit systems were typically minimal because of limited opportunities for technical change.[111] Notably, most agencies had reached the technological potential of fuel efficiency improvements.[112] Also, buses required the fixed ratio of one driver per vehicle.[113] K. A. Boame and K. Obeng examined vehicles miles of 24 U.S. bus transit systems between 1985 and 1997 using a Malmquist TFP index to decompose productivity change into technical change and efficiency change.[114] They found positive, and roughly equal, overall growth in both indexes.[115] However, both year by year and across the transit systems, the two indexes tended to move in different directions.[116] Interestingly, Boame and Obeng noted that subsidies usually have a negative effect on efficiency, perhaps by encouraging complacent management.[117] On the other hand, the fact that subsidies are predominantly allocated to capital expenses often leads to improvements in technology.[118] The aggregate effect of subsidies, according to Boame and Obeng, was neutral.[119]

Detailed decomposition of efficiency has allowed some scholars to isolate how scale efficiencies can affect measured productivity differently, depending on the size of the city or the type of scale being measured. Kristiaan Kerstens analyzed the efficiency[120] of up to 114[121] French urban bus transit agencies (in cities outside the Paris region) and found that smaller operators (about half of the observations) experienced increasing returns to scale while the larger operators demonstrated decreasing returns to scale.[122] Stephen Schmidt, looking at the impact of federal operating subsidies on the production functions of U.S. transit agencies, observed “scale economies for smaller firms, and scale diseconomies for larger ones.”[123] The metastudy of DeBorger et al. found the familiar U-shaped cost curve reflecting a similar pattern: increasing returns to scale for small firms, but decreasing returns for larger firms.[124] However, De Borger et al. claimed that scale inefficiencies were not, on the whole, a primary source of poor agency performance.[125]

Daniel Graham et al. took a different approach in their study of scale effects on productivity in the urban rail (heavy, light, commuter) systems of 15 major world cities.[126] Assuming agencies are already operating at constant returns to scale, Graham et al. distinguished between two types of expansion: returns to network (i.e., expanding the geographic scope with more or longer routes) and returns to traffic density (i.e., expanding service frequency with more vehicles on available routes).[127] Using passenger trips as their dependent variable,[128] Graham et al. calculated negative returns to network and positive returns to density.[129] This means that holding density inputs (labor and vehicles) constant, expanding networks leads to a “rate of output growth [that] lags behind the rate of growth in network size.”[130] Graham et al. interpreted their findings as evidence that some aspects of operating urban transit are beyond the “immediate control” of managers.[131] Nonetheless, managers who allocate their resources carefully over the long term might, presumably, avoid overexpanding a transit network faster than passenger demand would justify.

The importance of traffic density is echoed in other forms by many scholars, although not always with the same conclusions. Jeffrey Brown and Gregory Thompson found evidence, in their analysis of 73 small- to medium-sized U.S. metropolitan areas (population 500,000 to 5 million), that contradicted a number of papers from recent decades.[132] Their results showed that cities whose transit agencies opted for a more dispersed (i.e., multidestination) service orientation improved their “service productivity,” measured as passenger miles per vehicle mile, relative to the traditional hub-and-spokes networks.[133] Brown and Thompson attributed the positive results of multidestination routing to the efforts of transit agencies in those cities to serve increasingly decentralized distributions of employment.[134]

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NOTES

1 Though many U.S. urban transit systems contract out operations, the overwhelming majority of systems are managed by local or state government agencies. (See “Data sources” section of this article for a definition of directly operated and purchased transportation services. Also, see "Index of hours worked" section for a breakdown of employment along these lines.) Worth noting is that before 1950, private sector entities operated most urban transit systems, and continue to do so in many countries.

2 This was calculated by dividing the 2015 annual total of unlinked passenger trips for the transit modes in our scope by 365, producing a value of 27.664 million. (Unlinked passenger trips are equivalent to vehicle boardings, thus passengers who transfer to another vehicle during a trip are counted multiple times.) This calculation does not account for differences between weekday and weekend travel frequencies, which are usually substantial.

3 Public sector employment data come from the BLS Quarterly Census of Employment and Wages: Urban transit systems for state and local government. Total employment is derived from the authors’ own calculations; see “Index of hours worked” section of this article.

4 *2015 funding sources*, Federal Transit Administration, https://www.transit.dot.gov/ntd/data-product/2015-funding-sources. (The total includes 25 percent from fares and 9 percent from “taxes and fees levied by transit agency.” In addition, 4 percent of revenues came from *direct* sources other than passenger payments or subsidies. For example, revenues from advertising fall within this category).

5 See *Practices for evaluating the economic impacts and benefits of transit* (National Academies of Sciences, Engineering, and Medicine, 2017), p. 1, https://www.nap.edu/download/24768#.

6 Ibid., p. 63. (Agglomeration economies defined as “business productivity benefits gained from the ability of firms to tap a larger labor market, customer market, or supplier market, or increase interaction with other firms—all enabled by transportation network improvements.”)

7 Jason K. Phillips, “An application of the balanced scorecard to public transit system performance assessment,” *Transportation Journal*, vol. 43, no. 1, Winter 2004, p. 51.

8 Amy L. Freeland, Shailendra N. Banerjee, Andrew L. Dannenberg, and Arthur M. Wendel, “Walking associated with public transit: moving toward increased physical activity in the United States,” *American Journal of Public Health*, vol. 103, no. 3, March 2013, pp. 536–42, https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2012.300912 (used a national sample from the National Household Transportation Survey [NHTS] to demonstrate that cities with rail transit access encourage more overall daily walking); and Brian E. Saelens, Anne Vernez Moudon, Bumjoon Kang, Philip M. Hurvitz, and Chuan Zhou, “Relation between higher physical activity and public transit use,” *American Journal of Public Health*, vol. 104, no. 5, May 2014, pp. 854–60, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3987609/. (Analyzed detailed, direct physical activity data [captured by GPS devices and travel logs] of study participants in King County, Washington, to find that walking to transit increased overall physical activity of transit users relative to nontransit users.)

9 Jon D. Harford, "Congestion, pollution, and benefit-to-cost ratios of US public transit systems," *Transportation Research Part D Transport and Environment*, vol. 11, no. 1, January 2006, pp. 45–58, (in a study of 81 U.S. urbanized areas, calculated an average $1.46 in congestion savings per $1 in subsidies, with greater savings in larger cities such as Atlanta, Los Angeles, and Washington, DC [see table 2, pp. 54–55]); and Michael L. Anderson, "Subways, strikes, and slowdowns: the impacts of public transit on traffic congestion," *The American Economic Review*, vol. 104, no. 9, September 2014, p. 2794.

10 Michael Manville and Benjamin Cummins, "Why do voters support public transportation? Public choices and private behavior," *Transportation*, vol. 42, no. 2, March 2014, p. 329.

11 Brian D. Taylor and Eric A. Morris, "Public transportation objectives and rider demographics: are transit's priorities poor public policy?" *Transportation*, vol. 42, no. 2 (2015), pp. 351–2, https://www.worldtransitresearch.info/research/5756/.

12 Ibid., p. 363.

13 See *National Transit Database (NTD) glossary*, Federal Transit Administration, April 2018, https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary. (Demand response systems include "passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations.")

14 Metropolitan areas may include more than one large city center, such as Dallas/Fort Worth or Minneapolis/St. Paul. For more information, see *Chapter 13—Metropolitan areas*, Geographic Areas Reference Manual (U.S. Census Bureau, March 2013), http://www2.census.gov/geo/pdfs/reference/GARM/Ch13GARM.pdf.

15 Higher utility may derive from the quality of the transportation service (e.g., increased speed or capacity). However, some municipalities construct higher cost transit systems to promote positive externalities, such as reducing pollution and congestion or stimulating future urban development.

16 It is important to note that the political process is not assumed to be the most efficient way to provide public services. In some cases, investment in transit services may not lead to the promised or desired increases in ridership. Labor productivity statistics are, therefore, important because they show the degree to which public investments meet their goals.

17 For measures of efficiency and effectiveness that resemble labor productivity, including "cost effectiveness" (operating expenses per unlinked passenger trip), "cost efficiency" (operating expenses per vehicle revenue hour), and "service effectiveness" (unlinked passenger trips per vehicle revenue hour), see *Annual National Transit Summaries and Trends*, Federal Transit Administration, https://www.transit.dot.gov/ntd/annual-national-transit-summaries-and-trends.

18 John W. Kendrick, *Productivity trends in the United States* (Princeton, NJ: Princeton University Press, 1961), chap. 6, pp. 133–88. http://www.nber.org/chapters/c2243.pdf; John W. Kendrick, *Postwar productivity trends in the United States, 1948–1969* (New York, NY: National Bureau of Economic Research, 1973), appendix part II, pp. 190–95, http://www.nber.org/chapters/c3579.pdf.

19 John R. Meyer and Jose A. Gómez-Ibañez, "Measurement and analysis of productivity in transportation industries," in John W. Kendrick and Beatrice N. Vaccara, eds., *New developments in productivity measurement* (Chicago, IL: University of Chicago Press), pp. 295–332, http://www.nber.org/chapters/c3915.pdf.

20 Ibid., pp. 314–15.

21 Ibid., p. 315.

22 Ibid.

23 Ibid., p. 316.

24 *Urban transport, volume 2: appendices* (Productivity Commission of the Australian Government, February 1994), appendix D, pp. 81–118, http://www.pc.gov.au/inquiries/completed/urban-transport/37urbantv2.pdf. (This study measured productivity only at the agency level and did not attempt to aggregate the data to the national industry level.)

25 *Measuring state and local government productivity: examples from eleven services*, Bulletin 2495 (U.S. Bureau of Labor Statistics, 1998), pp. 62–80, https://www.bls.gov/lpc/iprprody.pdf.

26 *NTD glossary*, Federal Transit Administration, https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary. (NTD defines vehicle revenue miles as follows: "The miles that vehicles are scheduled to or actually travel while in revenue service.")

27 John W. Kendrick, *Productivity trends in the United States* (Princeton, NJ: Princeton University Press, 1961), pp. 508–10; and Kendrick, *Postwar productivity trends*, pp. 187–88, 193.

28 Ibid., pp. 513–19; pp. 191–92.

29 Mario Iacobucci and Joseph Schulman, "The productivity performance of Canada's transportation sector market forces and governance *matter*," The Conference Board of Canada, June 2009, https://www.conferenceboard.ca/e-library/abstract.aspx?did=3119.

30 Ibid., p. 9.

31 Ibid., p. 10.

32 Ibid.

33 Ibid.

34 *NTD glossary*, Federal Transit Administration. (Full reporters and reduced reporters submit data by urbanized area. Urbanized areas (UZAs) are defined as follows: "An urbanized area is an incorporated area with a population of 50,000 or more that is designated as such by the U.S. Department of Commerce, Bureau of the Census.")

35 *2013 urban module reporting manual*, Federal Transit Administration, September 2013, p. 2, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/2013_Urban_Reporting_Manual.pdf.

36 *NTD glossary*, Federal Transit Administration. ("Vehicles operated in maximum service" refers to the revenue vehicle count during the peak season of the year.)

37 See *2016 public transportation fact book*, 67th ed. (American Public Transportation Association, February 2017), p. 7, https://www.apta.com/wp-content/uploads/Resources/resources/statistics/Documents/FactBook/2016-APTA-Fact-Book.pdf.

38 For more information on how passenger miles are calculated, see *NTD sampling manual*, Federal Transit Administration, March 2009, p. 2, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/The_NTD_Sampling_Manual.pdf.

39 *NTD glossary*, Federal Transit Administration. ("Fixed guideway" is defined as a public transportation facility using and occupying a separate right-of-way for the exclusive use of public transportation, using rail, using a fixed catenary system, for a passenger ferry system, and/or for a bus rapid transit system. "High intensity motorbus" is defined as lanes that are exclusive to transit vehicles at some, but not all, times, and lanes that are restricted to transit vehicles, high occupancy vehicle, and high occupancy/toll lanes.)

40 *2013 small systems waiver reporting manual*, Federal Transit Administration, September 2013, p. 5, https://www.transit.dot.gov/node/8966. (Agencies providing fixed-guideway or high-intensity bus services are mandatory full reporters, even if they operate less than 30 vehicles in maximum service.)

41 Reduced reporters in scope for this article are limited to modes of bus and commuter bus. Reduced reporters accounted for about 2 percent of total bus trips taken in 2015.

42 Before 2015, gaps in capital expenses reported to the NTD, particularly for reduced reporters and purchased transportation services, led us to use American Public Transportation Association (APTA) data as the primary source for capital expenses. In 2015, NTD clarified the reporting requirements for capital expenses, leading to a fuller accounting of these data. Therefore, since 2015, we have used NTD as the sole source for capital expense data.

43 For more information, see "Industry productivity measures: estimation," *Handbook of methods* (U.S. Bureau of Labor Statistics, April 2015), https://www.bls.gov/opub/hom/inp/calculation.htm#output. (Törnqvist weighting allows the weights to change annually and is the standard methodology used by the BLS productivity program.)

44 The series of hours worked used for labor productivity measurement in urban transit systems differ from those used in the BLS productivity program's official database of hours and employment by industry (https://www.bls.gov/lpc/lpc_hours_dashboard.xlsx). The database of hours and employment by industry is based primarily on data from BLS's Current Employment Statistics (CES) program. CES employment data for urban transit systems is split into two separate categories—NAICS 4851, which covers privately owned establishments, and CES code 93248, which covers local government establishments. Neither of these datasets is detailed by mode, precluding our ability to exclude modes that are out of our scope, such as ferryboats, demand response, etc. (See "Industry definition" section.) Additionally, the CES series for local government establishments lacks data regarding average weekly hours. Aside from these shortcomings in the CES data, using labor data from NTD and APTA allows us to better match the precise establishments measured on the output side. This produces a more accurate final measure of labor productivity.

45 Calculated from NTD data as total passenger miles traveled (PMT) divided by total unlinked passenger trips (UPT).

46 Calculated from NTD data as total UPT divided by total vehicle revenue hours.

47 Available from NTD as VRH. This includes vehicle hours spent transporting passengers and excludes time spent repositioning empty vehicles.

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51 Surface rail includes both light rail and streetcar.

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